

Great Astronomers

Nicolas Copernik, better known by the Latinized form of his name, Copernicus, is believed to have been a German, although he was born at Thorn in Polish Prussia and was educated at Cracow University. He was first instructed in astronomy at Cracow, and learned mathematics at Bologna. Thence he went to Rome, where he was made professor of mathematics, and soon afterward he went into orders. On his return home he took charge of the principal church in his native place, and afterward moved to Frauenburg, near the mouth of the Vistula, where he spent the rest of his life. It is noteworthy that to Polish Prussia we owe the earliest of modern astronomers as well as the greatest of modern philosophers, Kant.

The revolutionary consequences of his hypothesis were not appreciated at the time, partly because his teaching was buried in a ponderous and learned treatise, partly because the teacher was an ecclesiastic, mainly because the Church was not yet ready to consent to state his views in quiet conversation and let them gently spread for thirty years before he published them. When he did publish them he dedicated his book to the Pope, and induced a Cardinal to bear the expense of printing. Thus the Roman Church was made to stand sponsor to a system of astronomy which was to revolutionize the century. It was destined to bury its anathemas and to inflict on its conspicuous adherents torture, imprisonment, and death. The achievement of Copernicus may

Nor are the difficulties involved in the conception of the earth as a sphere revolving round the sun only physical; they are still more felt from the speculative and theological points of view. The heliocentric theory of astronomy can hardly be considered complete. Theologians, indeed, do not deny the fact of the extreme subordination of the earth in the scheme of the universe, but many of them insist that the Bible and the Church acknowledge a perception of the tremendous and mysterious import of the doctrine of Copernicus, and would either to resist them or else to be false to its traditions. For the whole tenor of the Scriptures would be changed if they accepted the theory of the earth as a central body with all important body in the universe, if the sun and planets and stars were not attendant and subsidiary lights, but were other worlds larger, and perhaps superior to ours, where the Creator might be more fully glorified than here. The doctrine which the Church has maintained to be irrefutable? It was not to be expected that such a revolution would be accepted in a day, or in a century; and the Church has been patient, and has waited, and it is as a sufferer, and try to understand

...they are marrels of accuracy, and not a
...gave mistakes due to carelessness has ever
...was detected in them. For certain purposes
...connected with the proper motion of the stars
...and still appealed to, and they served as
...worthy data for several succeeding genera-
...tions of astronomers. It was long,
...after Tycho's death, before observations
...approaching in precision to his were made.
...the true sense of the word he was a pioneer.

II.

...if everything else that he did were forgotten,
...Tycho Brahe would still be remembered as the

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the earth shine like the moon, explained by earthshine the visibility of "the old man" in the new moon's arms." One of the most important of Galileo's discoveries was the discovery of the earth being a planet, and not a star. The earth was dull and dark, and did not shine like the moon does, and, in fact, rather like the moon, especially if it be covered with clouds. From the moon, the earth would look exactly like the moon, and the moon like the earth, and sixteen times as big. It is noticeable that Galileo made a very good estimate of the height of lunar mountains, of which some are five miles high and some as much as twenty miles. Wherever in the firmament Galileo saw a light, he supposed it was a star. The discovery of the Milky Way, which he supposed to be composed of stars. His most notable achievement was the discovery of the moons of Jupiter. His opponents contended that there were more than four, but no proof of this assertion was furnished until last year, when the astronomer Mr. Schaefer discovered the existence of a small fifth satellite of Jupiter, not improbable. It should also be remembered that Galileo invented a thermometer and a microscope. If we pass from Galileo's achievements in invention and observation to his achievements in pure mathematics, we must regard as his weightiest performance his reformulation of the laws of motion, the outcome of the application of mathematics to experiment. We have seen how he showed that all bodies fall at the same rate, except for the slight effect of the resistance of the air. What is the rate of fall? It is that a body which has dropped body falls is not proportional to the time simply, but to what is called the square of the time, that is, the time multiplied by itself. Thus, in one second, a freely falling body near the earth is found to drop sixteen inches. In two seconds it drops sixty-four inches, sixteen multiplied by the square of two, that is, sixteen. In three seconds it drops 144 feet, or sixteen multiplied by the square of three, and so on. The fact that the height through which a body falls is proportional to the square of the time, is the chief foundation stone of the earth's intensity of gravity may be regarded as an important discovery through ordinary small ranges. Although great distances gravity cannot be considered constant; under such circumstances the Galilean law of the square of the time is not applicable.

father Bruno was executed for heresy is disputed, but there is no doubt that he was imprisoned for teaching the plurality of worlds, the Copernican theory of the motion of the earth, and other heterodox doctrines. His death occurred in 1600, and his treatment would naturally make a deep impression upon Galileo. Nevertheless, while a professor at Padua, and not long after his father's death, he threw down the gauntlet in favour of the Copernican theory, and during his life he boldly proclaimed what Galileo would have called Ptolemaic atoms, which up to that

is removable. They who credit the story told by his muttering to a friend as he rose from the floor, and then, when he moved, do not appreciate the situation. It would have no friend in the place, and it would have been fatal to mutter any more before such an assemblage. Moreover, he was by this time an old man, and he would have been most wretched at all things to get away and hide himself and his miseries from the public gaze; probably his senses deadened and stupefied by the mental sufferings he had undergone, and no longer capable of any other feeling than contempt, perhaps, his daughter, who was then young, on her deathbed. Condemned to a solitary existence at Arcetri, he yet found energy enough to compose the dialogues in which the true laws of motion are set forth for the first time, and to make the most beautiful of his most solid achievement. One astronomical discovery he was to make, and that of the moon's libration, and then fell ill of a crushing blow: he became totally blind, and he died in the arms of his daughter, who was visited by John Milton, who has recorded a pathetic incident in one of his most memorable prose compositions, and who was destined in his old age to suffer the same fate.

those who exult experiment at the expense of deduction, Mr. Lodge points out that Descartes was a precursor of Newton in this respect, that his general method of research was nearly as possible a purely deductive method as may be, he starts after the manner of Euclid with a few self-evident axioms, and from them reasoning endeavors to deduce from them their consequences, and so to build up, bit by bit, an edifice of connected knowledge. It is true that this method cannot safely followed without continual appeal to the senses, but in this respect, though not perfectly following the necessity for such latitude which Descartes erred. His importance lies less not so much in what he actually covered as in his anticipation of the right conditions for the solution of problems in the science of nature. In fact, made the discovery that nature could afford to be interrogated mathematically, a fact was in great danger of remaining unknown. A reaction against deductive reasoning had set in, led by Galileo, and the great scientific method of the modern scientific philosophy, and lasting down to the present day. It is not true, however, that only right way of investigating nature is experiment and observation. This, is, in an absolutely necessary way, but it is not the only way. The foundation of experimental fact there must be, but the logical structure of theoretical deductions can be based, all rigidly connected together by reasoning, and all necessarily as true as the premises, provided no mistake has been made in the process. To prevent the possibility of error, or oversight, or error, or error (or later) be brought to the test of experiment. If the test cannot be borne the theory itself must be re-examined and the flaw discovered, or else the theory must be abandoned. The deductive method, which in the hands of Newton, and in the hands of his results, and which combined with experiment, has made science what it is, we owe the thinking and early stages to Descartes.

free copies of this volume are devoted to the study of the book, and in one of them a similarly important principle is discovered and set forth in the Principles. The book is given in popular language, without recourse to technical terms, we shall present some features of it. But, first, we recall hastily the chief outward features of the book. The author, who has said, in 1842, "I am now 77 years of age," was born in 1727, at the age of 15, the year Isaac was removed from school to be made a farmer of, but as he did not promise to turn out a good one, his father, John, who was a parson, arranged for him to go to school and then to the law, and him back to school and then to the law, where he entered Trinity College at 18, in 1801. The Cambridge men used to sneer at sizars must not forget that Newton was one of

The meaning of the discovery might be that the world is not as simple as it appears. The discovery might be that the world is not as simple as it appears. The discovery might be that the world is not as simple as it appears.

amount of this variation and showed 194 pounds at the pole would balance 305 pounds at the equator. He then proceeded to demonstrate that the earth's equatorial precession, being acted on by the attraction of the sun, must disturb his axis of rotation in a calculable manner, and thus produced the so-called precession of the equinoxes. Again, the waters of the ocean are attracted toward the sun and moon on one side and whirled a little further away than the other on the other side; hence Newton maintained that the ocean is not perfectly level. The sun's mass being known, he calculated the height of the solar tide, while from observed heights of spring and neap tides he determined the lunar tide, and thence made an estimate of the mass of the moon.

Newton's theory of gravitation, which was setting in the "Principia" and presented Lord, Lodge with remarkable distinctness and simplicity. It is hard, indeed, for any one to realize the tremendous flight in knowledge which was needed to span the distance between the discovery of Kepler, three hundred years ago, and the calculations of Descartes and, on one hand, and Newton's magnificent grasp of comprehensive and well-ordered knowledge. To many of Newton's contemporaries it seemed as if there were nothing more to be discovered—as the universe were now understood and that the fragments of truth were gathered for the gleaner. Newton himself was far from imagining that he had exhausted possibilities of discovery. It was when he was an old man, venerated and almost worshipped for his coevals, that he uttered the words, "I am like an ant, who, for fragments of truth, will think of my labors, but to myself seems that I have been but as a child playing on the seashore, now finding some pebbles rather more polished and now some shells rather more agreeably variegated than others, but in no instance having been able to extend myself unexplored before me."

VI.

THE closing of Newton's death was

veries were made by another English-
Prof. Bradley of Oxford, namely the aberr-
of light and the nutation of the earth's
-Bomø fifty years earlier, a Danish astron-
-Roemer had surmised that light did not
-travel instantaneously, but that it had a
-of motion was compounded with the
-of the earth. Bradley demonstrated
-istence and the cause of the aberration
-it, and pointed out the method of deter-
-ing its velocity. The velocity of light he
-determined to be 193,000 miles a second,
-the velocity of the earth in its orbit; that it
-could be 190,000 miles a second, not five
-cent from the speed Roemer had con-
-ected in order to explain the anomalies of
-er's first satellite.

the existence of nebular hypothesis
-It, indeed, had been suggested by Kant,
-which has been principally commended to
-onomers by Laplace. The latter worked

The nebular hypothesis was thrown out by place, not as the outcome of profound calculation, like the demonstration of the stability of the solar system, nor as following directly from the theory of gravitation, and therefore it is not to be accepted as more than a mere speculation, to be confirmed or rejected as our needs. Since the time of Laplace the nebular hypothesis has been up and down of credence, but at no time has it held the field with apparently greater probability of ultimate triumph than ever before seemed to belong to it. With the help of Prof. Lodge, let us try to tell the nebular hypothesis in a compact and intelligible form. We should, in the first place, recapitulate the data on which it is based. These are: Every motion in the solar system known, and every motion known in one direction, and in one direction only. Thus the planets revolved around the sun, all going the same way round, moons

aligned toward the planets, still maintaining the same direction of rotation, and all the same, were then known to rotate on different axes, in the same kind of direction. Moreover, all these motions were toward a single plane. The ancients knew of the sun, moon, and planets all kept near to the plane of the ecliptic within a belt known as the zodiac; none strays away into other parts of the sky. The planets, however, are arranged in or near the same plane, and the axis of diurnal spin or equator of the diorbits is but slightly tilted.

Manifestly, all this could not be the result of chance connection or coincidence. There is a connection or common ancestry, and that is not for this strange family likeness? There is a connection now, but may there not have been a once one? Must there not have been a common ancestor? It seems as though the planets and the stars of our great mass rotating as a whole, for example, when it broke up, its parts would retain its direction of rotation. But such a mass filling space as far as or beyond Saturn, although retaining the materials of the whole solar system, would not have been of very rare consistency. Occupying space, it might not have been solid, nor yet liquid, but might have been gaseous. Are there any gigantic rotating masses of gas in the

ens now? Certainly there are; there are nebulae. Some of the nebulae are now gaseous, and some of them, at least, are in a state of rotation. Laplace did not have known this for certain, but he detected it. The first distinctly spiral nebula discovered by the telescope of Lord Rosse, and quite recently a photograph of the great Andromeda nebula, made by Mr. C. Roberts, demonstrates that this prodigious mass is in a state of extensive and majestic whirl.

The problem presented by the data is the following: A vast mass of rotating gas is left to itself to cool for ages and to condense as it cools; how will it behave? Laplace pictured the condensation of the nebula, and thereby the spinning more and more rapidly, the nebula shrinking in size and retaining its original rate of rotation, as it will unless a brake is introduced, must spin more and more rapidly as it contracts. It has what mathematicians call a constant angular momentum, and the loss in levelled surface as it shrinks it gains in speed. It is held together by gravitation, every particle attracting every other particle, but, since all particles are describing curved paths, they tend to fly off tangentially, and only a centrifugal force, the centrifugal force over the mutual gravitation of the particles, holds them, and slowly to concentrate the nebula. The mutual gravitation of the parts is opposed by the centrifugal force of the whirl. At length a point is reached where the centrifugal force is equal to the gravitation; a certain line will be in equilibrium, the rest left behind, and the rest must contract until a ring is formed, and away goes the inner nucleus, contracting further and further toward the centre. After a time another ring is formed, and so on. What happens to these rings? Do they rotate with the motion they possess when thrown or shrunk off, but will they re-rotate? If perfectly regular they may; but if irregular, they are liable to be thrown off, or to be thrown on, or to form large masses, which are able to collide to collide and become one. The spinning body so formed is still a rotating mass, and it will go on shrinking and throwing off rings like the nebula, as by which it is formed. As the nucleus gets smaller, its rate of revolution increases, and so the rings are thrown off more spinning faster than those thrown off before. The final nucleus or residual central mass is left, and the rings are thrown off.

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VII.
have but little space in which to touch on
the six chapters of Mr. Lodge's book,
though these cover the field of recent astro-
nomical discoveries, some of which are of ex-
traordinary interest, and only say of
William Herschel that he was the first as-
tronomer, he first drew attention to Uranus.
He himself suspected to be a comet, but
was discerned to be a planet by profes-
sion astronomers; that he subsequently dis-
covered the moons of Saturn and two of
Jupiter, leading to 2,500 observations of the
planets that he reviewed, described, and
named all the visible heavens, and finally dis-
covered that the stars were not fixed, but in
motion; and that the sun, as one of them, was
moving toward a point in the constellation
Cygnus, and that the quantity of mat-
ter of his work, we must leave to Sir
William Herschel the greatest of observers

the meaning of the figures representing the distance of the stars. Prof. Lodge essays to help us to comprehend them by the following question: "Suppose," he says, "we could harness some sort of telegraphic vehicle able to travel at the rate of 100 miles a second, to carry us from New York to Liverpool in the time it takes a drop—that is, in the time required to drop two inches—such a vehicle would reach the moon in twelve seconds and would be able to return to earth in 24 seconds." "Well," he asks, "if we are travelling thus continually, in twenty-four hours we should have the last member of the star system behind us and begin our plunge into the depths of space. How long would it take before we encountered another object? For that matter, would one guess? Twenty years we should have to journey with that prodigious speed before we should reach the nearest star. And should we not wait twenty years before we should reach another? And so it would be, for each of the stars is scattered from one another as the stars scattered in space; and were they not brilliantly

luminous like our sun, they would be
completely invisible. There are, no doubt, multitudes of stars that
are less visible to us, and some that
are not so densely packed as the
stars. We have seen that the quickest moving
stars are those known as O1 Cygni and
Cambridge 1830. Owing to their relative
nearness of motion, they have been de-
termined to be the actual speed of
Cambridge 1830 is about 200 miles a
second. The whole visible area of the
universe is about 200 miles a
second. Therefore, the universe is immensely larger
than anything we can see with the most pow-
erful telescope. It is a vast sea of
invisible non-luminous stars mixed up
with others, immensely multiplying the at-
tactive power of the orbs visible, the
known as Groombridge 1830 can
be a temporary visitor to this frame
of things. It is travelling in the
distance through an infinite distance. It is
in distance through our visible universe for the
time and only time; it will never return. Yet
the gigantic is the extent of visible space, that
the distance of the space of 200 miles
a second this star will need of 200 mil-
lion years to get out of sight of our present
telescope, and several thousand years before
it is perceptibly fainter than it is now.

VIII.
would not wholly overlook a chapter in Prof. Lodge considers the nature of pores or so-called shooting stars. We ordinarily see them as mere streaks of light; sometimes they leave a luminous tail behind; occasionally they appear as actual balls, accompanied by explosions; sometimes, but very seldom, they are seen to drop, and may subsequently be dug up as lumps of iron or rock, showing signs of rough treat-

by exorcisation and hent. These last are meteorites or aerolites of our museums. The people are apt to speak of as thunderbolts, and they have nothing to do with the etheric electricity. They are small, rolling rocky or metallic fragments which, on their journey through space, are caught in the atmosphere, and instantaneously are hurled through the air, and are scattered in the depths of space one of these wandering bodies being the attracting power of the sun. As it approached, its speed increased, and greater and greater until it reached its proper destination, the earth, from the sun, it whizzes with the velocity of twenty-six miles a second, and will be seen as a bright meteor, moving on its own account nineteen miles a second. If the two bodies happen to be moving in the same direction, the meteor will be terrific; and the faintest trace of a meteor miles above the earth's surface will be seen as a bright meteor.

A stream of particles would be torn off;

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the moon's rotation relative to the sun, and destroyed by past tidal action on it. The only residue of ancient lunar rotation is the fact that the moon is tilted. Moreover, according to the theory of tidal friction, the earth's rotation is steadily increasing, and the moon's motion must have been much slower. To quarter, or indeed to half, the distance of the moon would make the tides sixty-four times as high as they are now.

It is, lastly, a curious fact that the moon revolves around it more than twice as fast as it rotates. If it were revolving from it, they must be approaching it, and their stones day crash along its surface. The moon is now 240,000 miles away, and revolves in twenty-eight days and a half, while the earth is 93,000,000 miles from the sun, and takes a year to revolve. The moon is consequently, if composed of

TO THE EDITOR OF THE MINN-AP: Complaints to the present condition of this city are meretricious, but suggestions as to remedy are being poured out the vials of our wrath on the city authorities, let us consider individual responsibilities in the uniformity and disorder of our streets, cars, and all public places. Neither the wisdom of Solomon nor the strength of Samson, with two millions dollars annually to back them, could keep a city clean while a million of people do their utmost to make it otherwise. Respectable men and women fear to let letters in newspapers, and scatter them on the sidewalks; lawless men and women scatter advertisements and toss them up and down the streets; milkmen leave huge cartloads of tin cans standing on the Boulevard all day Sunday.

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and throwing the refuse into the streets, and the coffee grounds, tea leaves can all be easily cleaned up. The ashes, kept dry and free from rain, are sold to the farmers in the suburbs of the city, or on vacant lots in the country. The refuse is dumped on Long Island and New Jersey. It is not so little to burn in private stoves, but it is not so difficult to range and furnace during the winter, and the portable furnaces could be used in the summer for heating the water for law, medicine, and theology; now let them have enough of the science of chemistry to make a good use of the refuse and make the best deodorizers and fire.

This city is best to be cleaned, women must do it. The streets are not cleaned for two or three centuries; they have aged, twisted over the problem, talked, and the streets are not cleaned. The Street Commissioners up in their physical tweezers in long sermons and long letters to the city fathers, and grow with empty their serap baskets, full of rats, cigar stumps, toothpicks, red tape and

never so papers scattered about in the streets of London or Paris, nor anything so common as to find a newspaper lying in all our American cities and villages. As they are flying in all directions, and our eyes are everywhere catching the pigmy at the end of a day's journey, it is a pity that the American people are not doing conveyances for the sovereign people of the world.

The Exposition is to open in Chicago in a month, we shall have visitors here from all parts of the world, and their first impression of us as a people will be the appearance of the streets of our metropolis. Let every citizen, every visitor landing on our shores in the spring, find the streets of Chicago as they will pry into all the nooks and corners of the lanes and courts, and punish us for the dirt and filth which they find. If enough cleaning of all our cities we shall see the success of the Exposition, altogether. Let us not, therefore, find any excuse, make any excuse for all our shortcomings. Let the foreigners will judge of our civilization by the cleanliness and order of our streets and alleys.

ELIZABETH CADY STANTON.

LOOKING IN THE GYMNASIUMS.

The athletic schoolboys are taking all the stages of gymnastic work nowadays. At Berkeley the candidates for the athletic team report in active daily training. Dudley and the two leading candidates continue to improve, and they will be Berkeley's only representatives in the 100-yard dash for seniors. The junior 100-yard dash, in which only under 16 years old will be allowed to compete, has Hien, Bower, Field, and Wilson will represent Berkeley. The basketball has quite promising broad jump in Bowers.

A pole vault is one of the new interesting events, and as yet there are only a few candidates. At Berkeley only one had his first jump introduced into view, and he is Fred de Groot. Dick Elliot is doing well in the 440-yards race in the state meet. In the 880 yards, D. De Forster, and Pier are running well.

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One of the city has returned from a recent trip to the Yucatan, and has brought back a number of interesting relics and discoveries. The greatest discovery which he reports is the finding of a mummy, which he says is the mummy of a woman. He says that he found it in a cave, and that it was in a state of perfect preservation. He says that it was found in a cave, and that it was in a state of perfect preservation. He says that it was found in a cave, and that it was in a state of perfect preservation.